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Wavelength Scanning Interferometry for PV Production In-line Metrology

Original Citation

Elrawemi, Mohamed, Blunt, Liam, Fleming, Leigh, Muhamedsalih, Hussam and Gao, F. (2014) Wavelength Scanning Interferometry for PV Production In-line Metrology. In: 3rd Annual EPSRC Manufacturing the Future Conference, 23rd – 24th September 2014, Glasgow Science Centre, Glasgow, UK.

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Background

Flexible PV modules are manufactured using roll to roll (R2R) technology. These modules require a flexible barrier material to prevent water vapor ingress.



Fig. 1 Roll to Roll technology [1]

Thin Film PV Modules

Flexible solar modules comprise four functional layer groupings. The main focus of the investigation in this work is the barrier layer, this layer is typically formed from a planarised Polyethylene Naphthalate (PEN) sheet with an amorphous Al_2O_3 barrier coating $<50\text{ nm}$ thick.

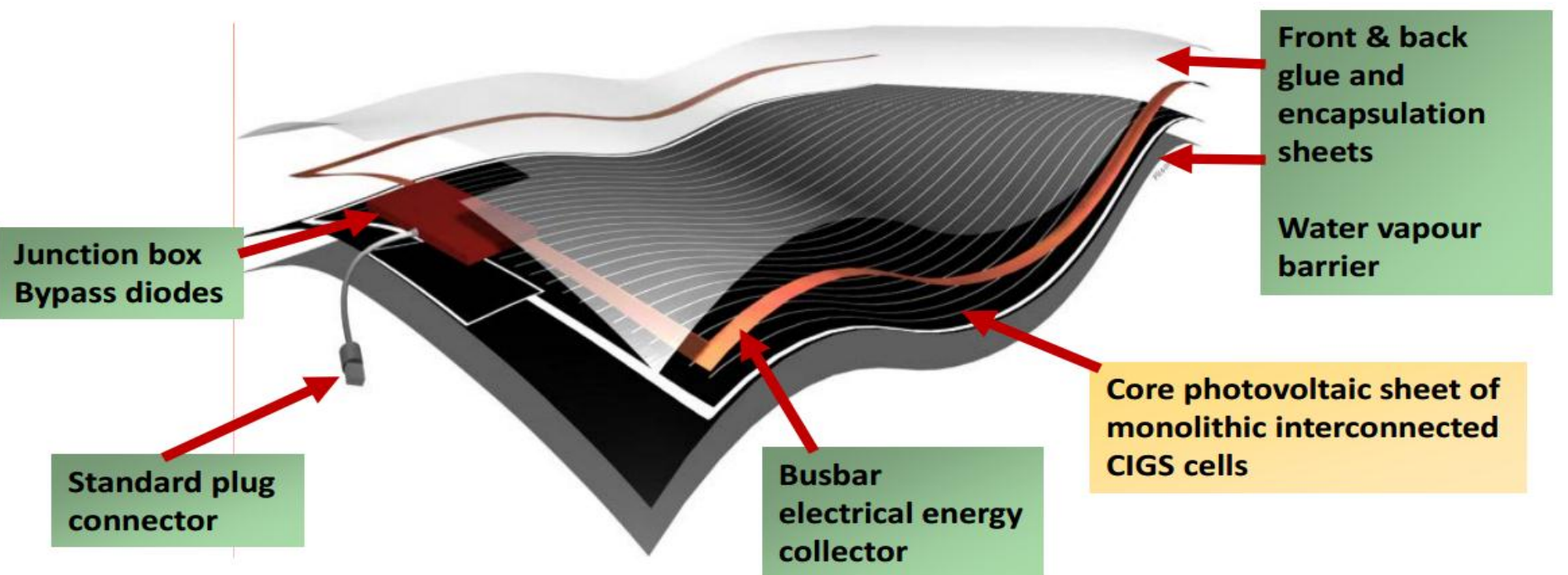


Fig. 2 Flexible PV modules [Courtesy of Flisom, Switzerland]

Al_2O_3 ALD Barrier Film

Thin layers of Al_2O_3 of deposited via the atomic layer deposition technique (ALD) using R2R technology, have been introduced to allow PV modules transparency, flexibility and to provide an effective barrier layer. The process uses Trimethyl Aluminium (TMA) and water precursors and the tuned process temperature is $105\text{ }^\circ\text{C}$

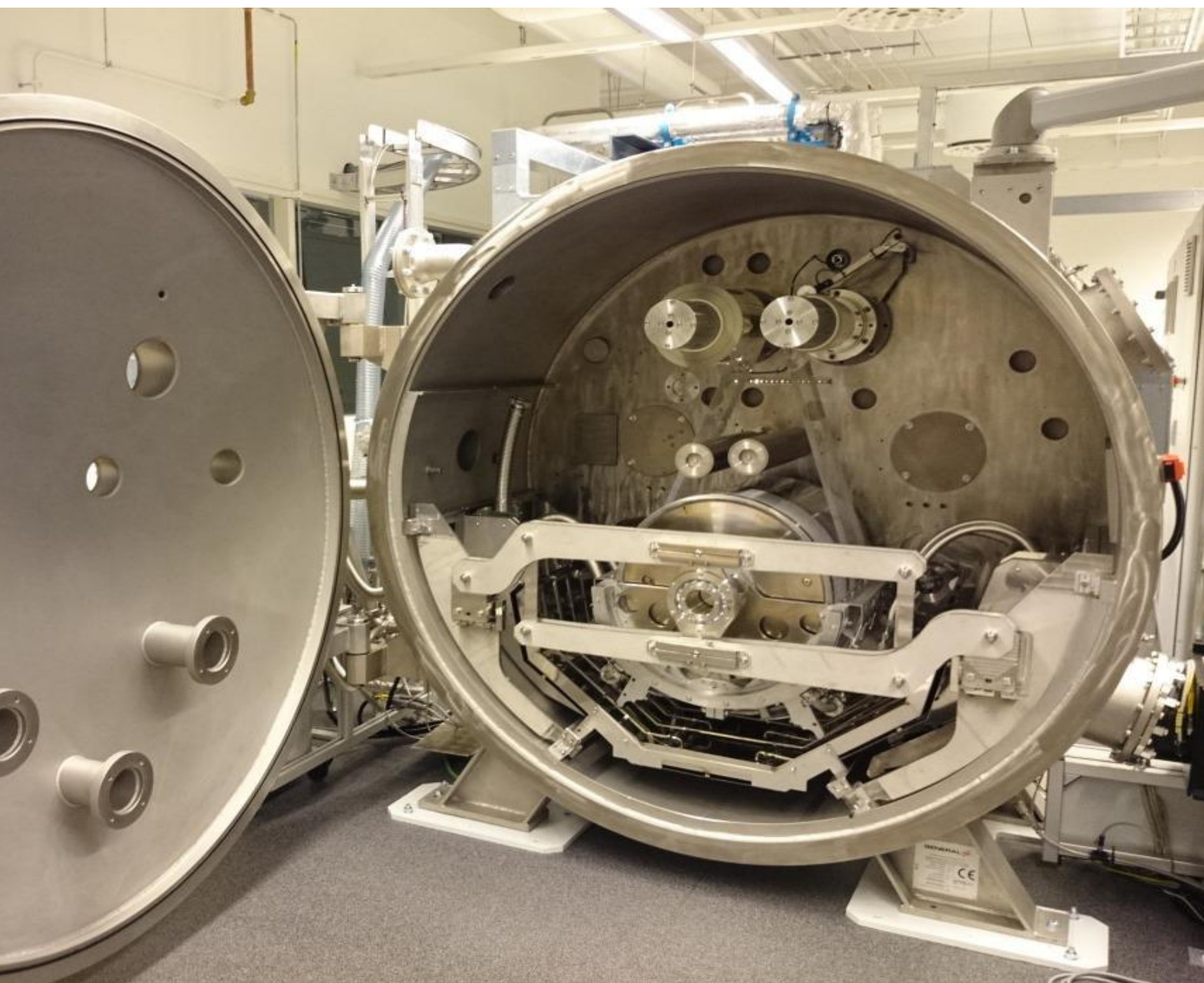
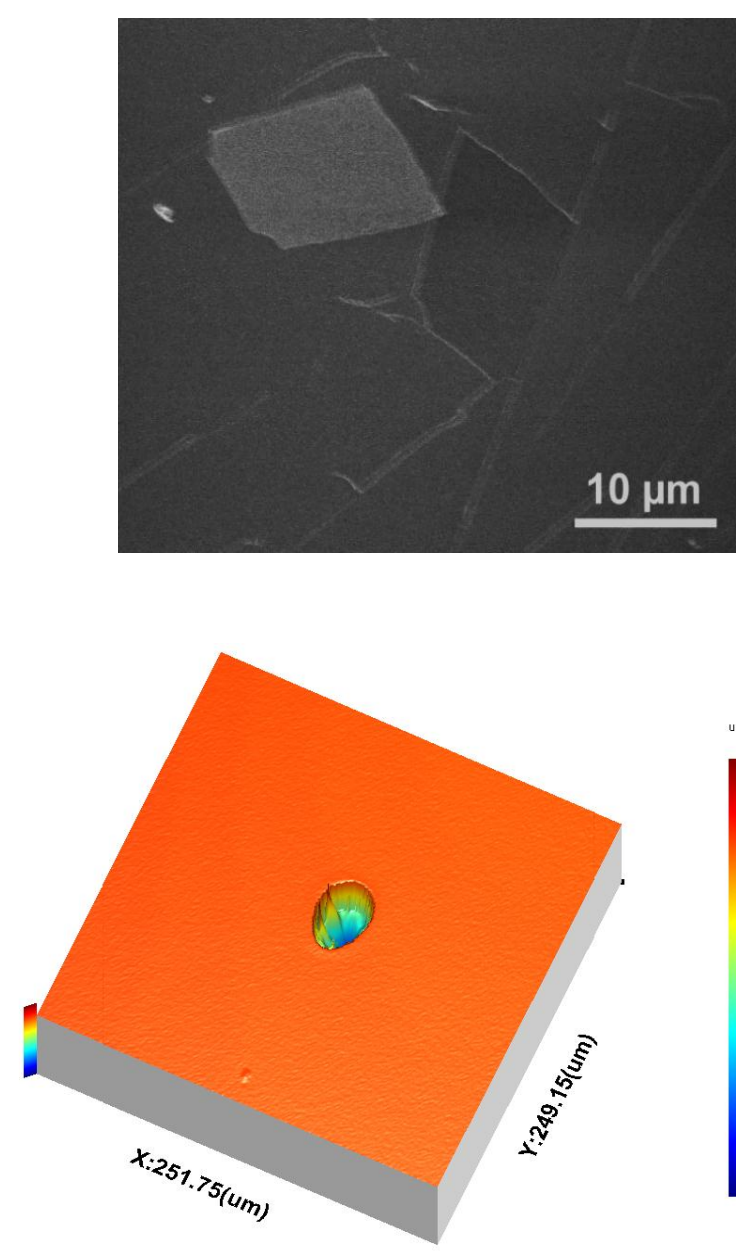


Fig. 3 Beneq WCS 500 roll-to-roll ALD reactor

Problem Statement

Micro and nano scale defects that occurs during the deposition process of PV barrier films not only degrade the PV module performance over time but lead to the scrapping of high value products. The overall aim of this study is to develop in process metrology systems to detect the PV barrier films defects.



Experimental work

Two representative Al_2O_3 ALD samples processed by the Centre for Process Innovations (CPI). These samples have an 80 mm diameter area that has been ALD coated with 40nm Al_2O_3 .

The WVTRs of the study were carried out at the National Physical Laboratory (NPL) using a traceable in house developed instrument.

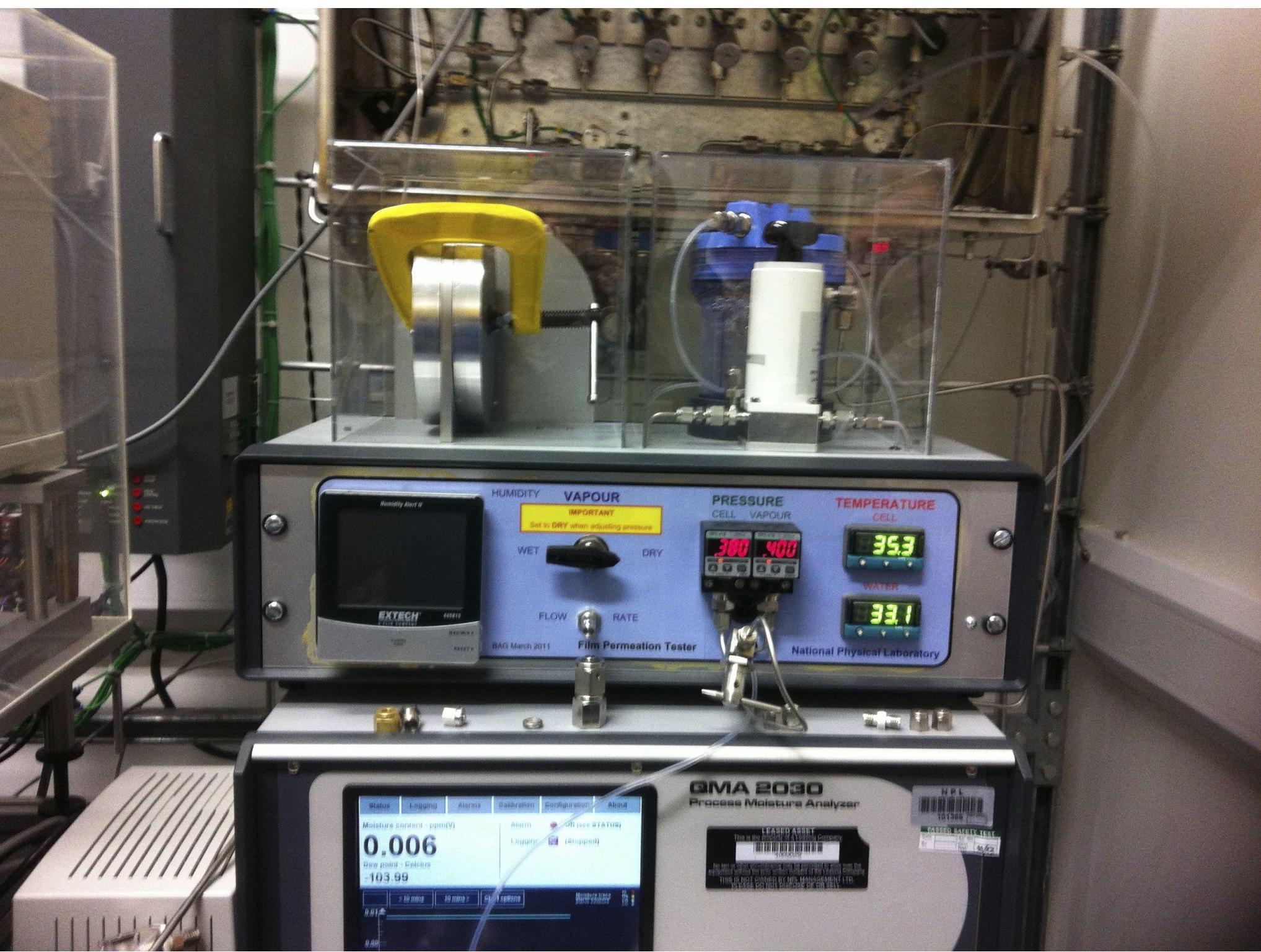


Fig. 4 WVTR test instrument

WVTR test results

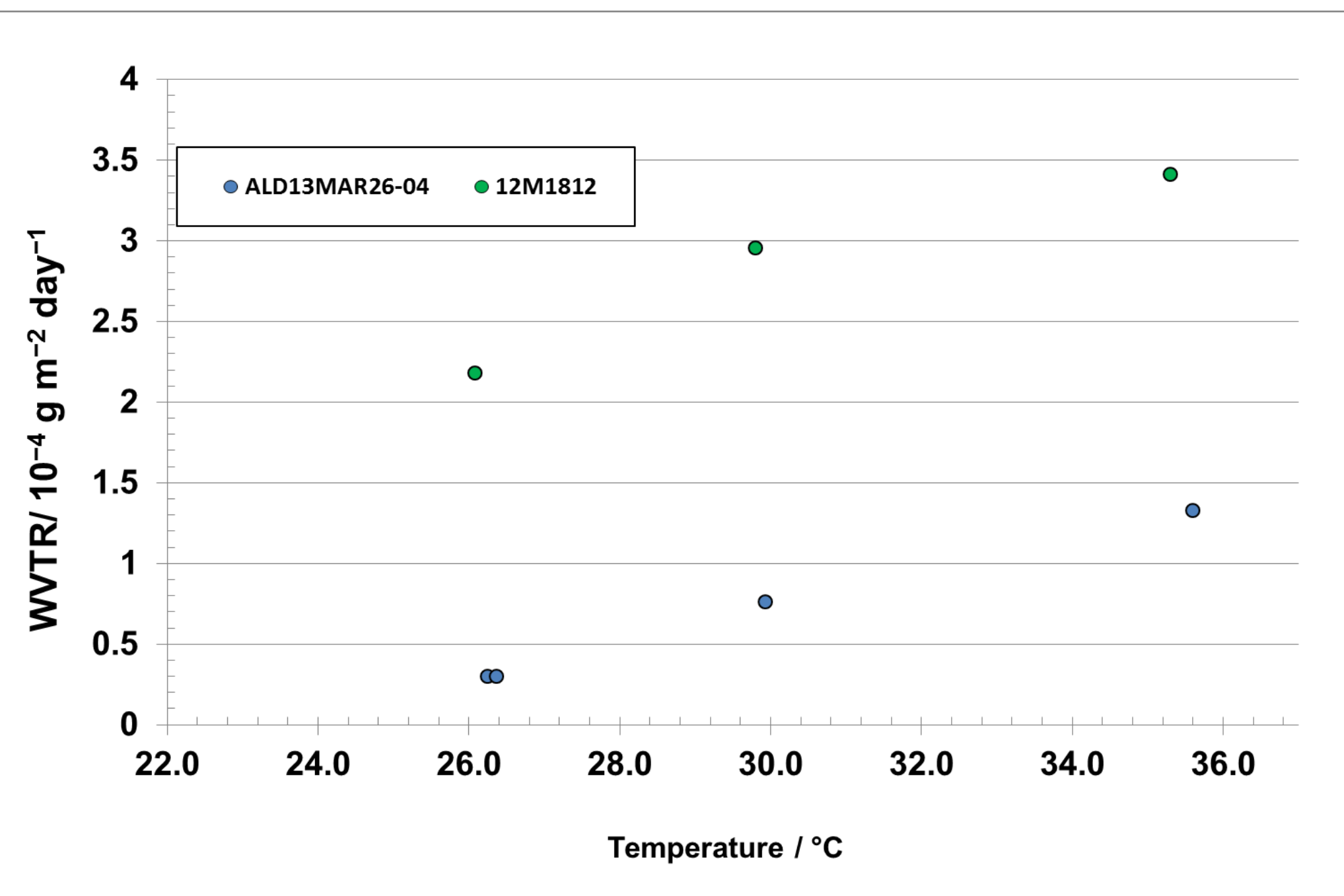
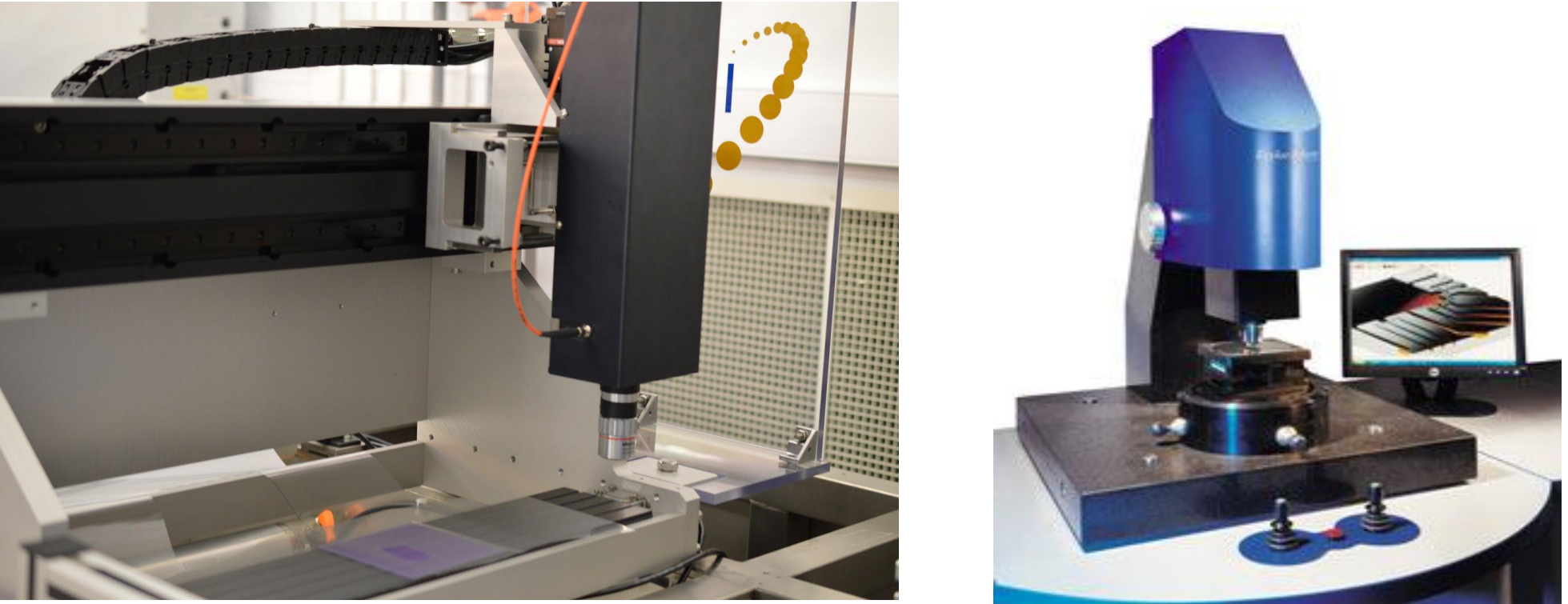


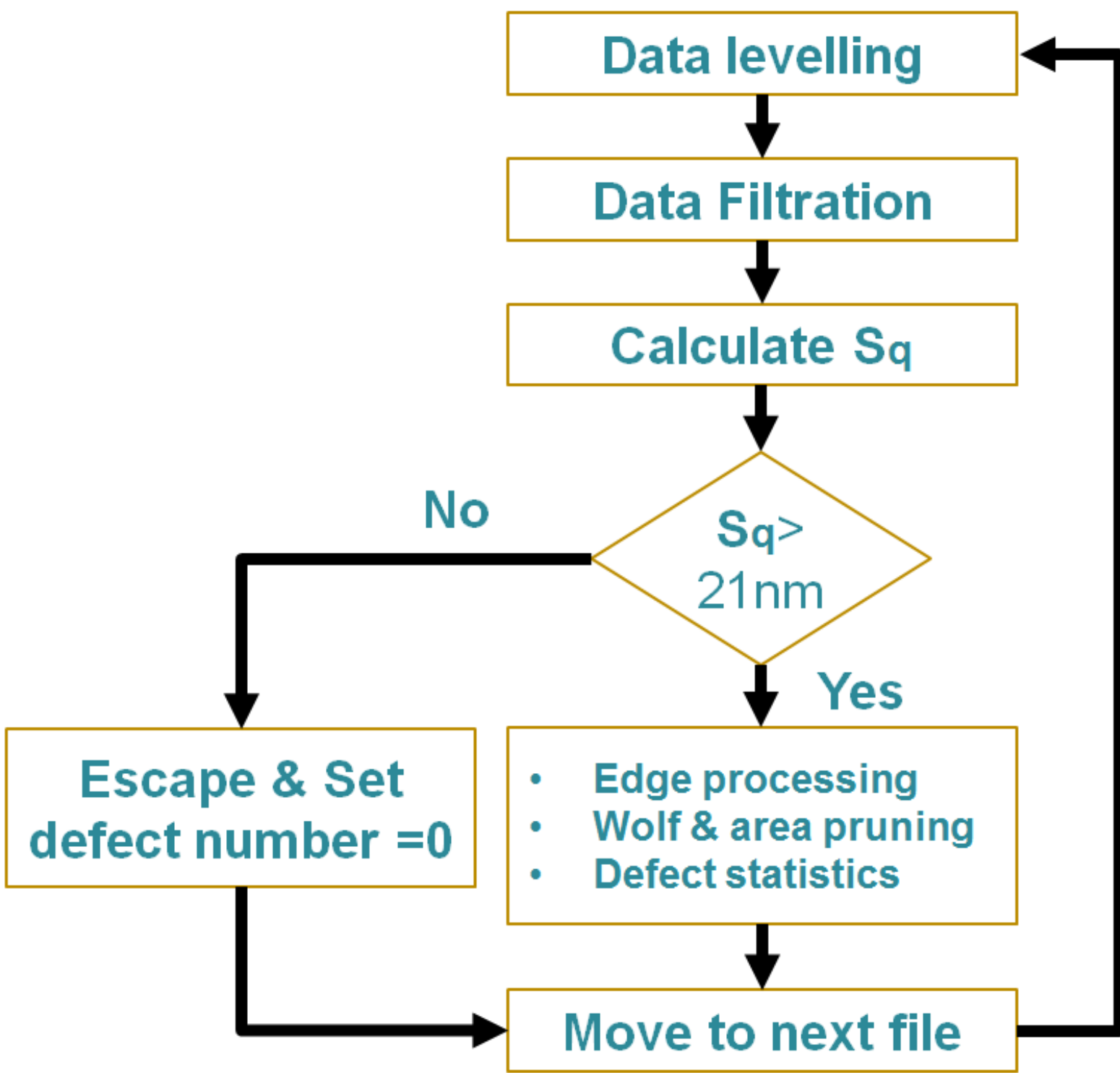
Fig. 5 shows WVTR for 40 nm ALD barriers at different temperatures between 24-36 $^\circ\text{C}$

Surface Characterisation

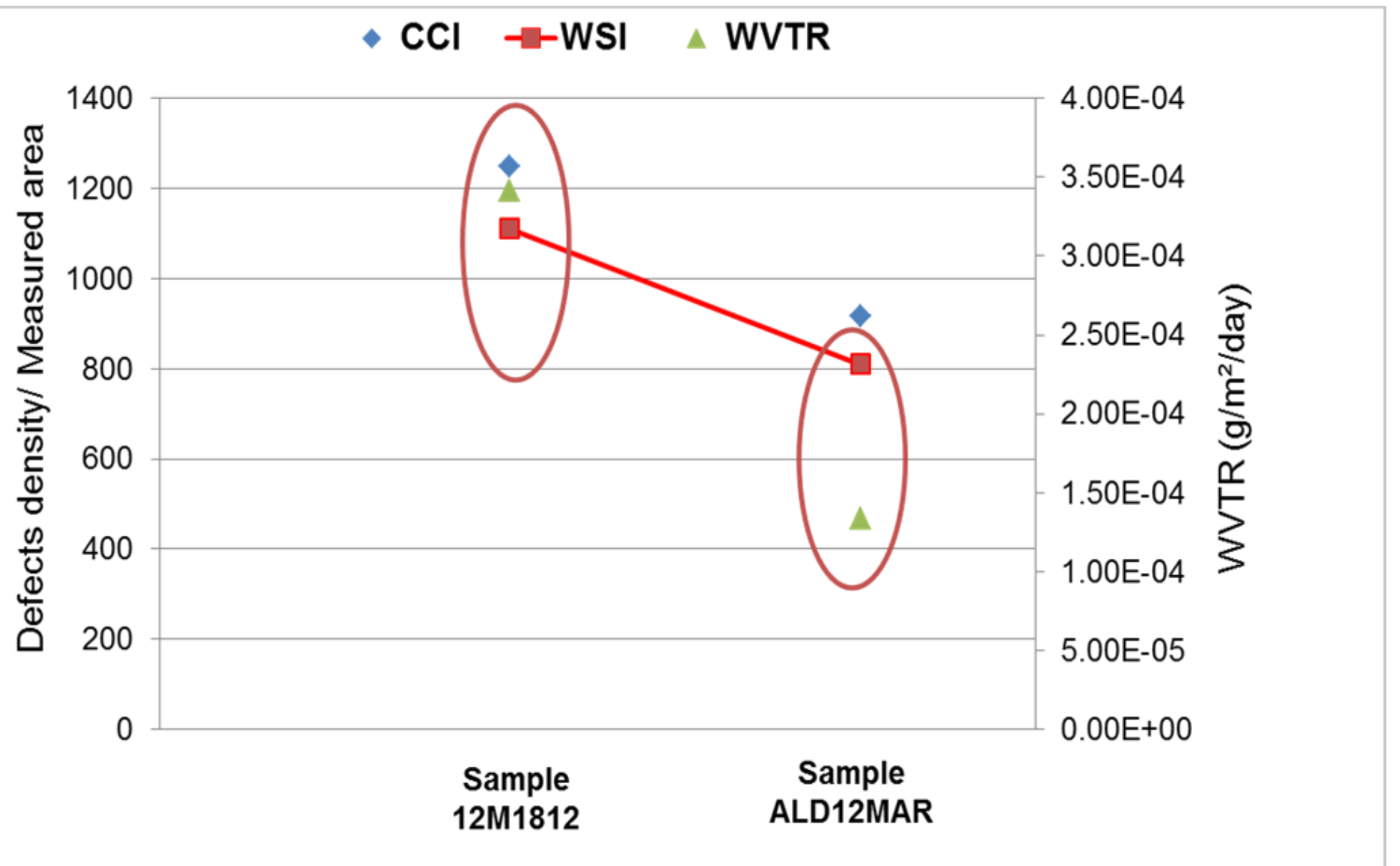
This study provides a performance comparison between a newly developed in process instrument based on wavelength scanning interferometer (WSI) and off-line coherence correlation interferometer (CCI) to detect micro-scale defects. This is done in order to verify the applicability of WSI to be installed in R2R technology.



Defect extraction and statistics



Results & Conclusion



- The analysis of the results appears to indicate that sample with higher density of large defects exhibit inferior barrier properties.
- WSI results compare favorably with Coherence Correlation Interferometry (CCI) results.
- The results provide basis for development of a proof of concept system.

Acknowledgement

To EPSRC via EU FP7 programme for NanoMend project NMP4 LA-2011-280581 and Libyan Cultural Attaché in London

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1. Y. Galagan and R. Andriessen, "Organic photovoltaics: technologies and manufacturing," 2012.
2. International Standard (2012). ISO 25178-2:2012(E), Terms, definitions and surface texture parameters. Switzerland. 1-47.